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The Growth in Inter-connectedness in the Scottish Economy, 1998-2007; a disaggregated analysis.

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Abstract

The measurement of inter-connectedness in an economy using input-output tables is not new, however much of the previous literature has not had any explicit dynamic dimension. Studies have tried to estimate the degree of inter-relatedness for an economy at a given point in time using one input-output table, some have compared different economies at a point in time but few have looked at the question of how inter-connectedness within an economy changes over time. The publication in 2010 of a consistent series of input-output tables for Scotland offers the researcher the opportunity to track changes in the degree of inter-connectedness over the seven year period 1998 to 2007.

The paper is in two parts. A simple measure of inter-connectedness is introduced in the first part of the paper and applied to the Scottish tables. In the second part of the paper an extraction method is applied to sector by sector to the tables in order to estimate how interconnectedness has changed over time for each industrial sector.

Keywords: Extraction method, Input-Output Analysis, Inter-connectedness, Scottish economy,

JEL Classification: R11, R12, R15

1. Introduction

The recent publication of consistent annual input-output tables relating to the Scottish economy for the ten year period 1998 to 2007[1] provides a data resource of a type that is rare in regional economics. As yet there appears to be little, if any, published work analysing the behaviour of the Scottish economy over the turn of the millennium as evidenced by these tables. This paper attempts to use the tables to investigate whether the Scottish economy was becoming more or less inter-connected (or more or less complex) over the period.

As a region develops it is subject to a great variety of economic, demographic and social forces which will affect its economic structure. Some forces act to increase the variety of the region's economic activity. For example, the existence and growth of one industry may encourage firms in industries that supply inputs to the first industry's production process to locate in the region. Equally growth of personal disposable income in a region might stimulate local consumer goods industries. In such cases there would be some reason to suppose that, c*eteris paribus*, a degree of import substitution might take place with intra-regionally provided goods and services displacing those previously externally provided. In such a situation the regional economy in question might be said to have become more inter-related or complex as both a greater magnitude and variety of transaction flows between agents in the regional economy would be evident. Such increased inter-connectedness would tend to reduce the dependency of the region on other areas and hence reduce the relative importance of inter-regional trade. The effect is likely to be moderated if the new activities which replace imports in their turn require inputs that are not provided locally. Naturally in cases of regional decline the reverse can occur. Firms that close reduce the market for other firms that were supplying them. Loss of income in the local economy reduces demand in that economy. In reality one would expect regions to experience a measure of growth and a measure of decline simultaneously as some firms and industries prosper whilst others falter.

In the particular case of the Scottish economy over the period 1998 to 2007 there is an additional factor that could have led to increasing inter-connectedness of the

[1] http://www.scotland.gov.uk/Topics/Statistics/Browse/Economy/Input-Output/Downloads

economy. Scottish devolution became a reality in 1999 with the commencement of the current Scottish Parliament. If this movement to devolution was accompanied with a growth in sympathy for sourcing supplies from Scotland it is likely that it would have reinforced any moves towards greater inter-connectedness.

One other major factor that can be expected to have had an effect is the process of globalization. On a global level trade between countries has grown more quickly than the GDPs of countries. There is no reason to suppose that a similar growth of international and inter-regional trade would not also have happened at a regional level. Such growth in trade, part of which may be ascribed to firms taking advantage of different competitive advantages, would have the effect of increasing both the international and the inter-regional trade of a region at the expense of domestic inter-industry trade; further one would expect to see, in an economy that was exploiting its own relative competitiveness, alongside the growth in imports as a result of such globalization a similar boost to exports.

A further complication might arise from the recently observed phenomena of out-sourcing and off-shoring. Out-sourcing, a circumstance in which a firm buys in from other firms goods or services that it was hitherto providing for itself, might be expected to increase the inter-connectedness of the regional economy if the new provider of the input was locally based but not if it was a foreign firm. Although essentially a new imported intermediate input would replace something that was previously accounted for in value added the regional economy would be likely to lose any intermediate transactions that serviced the activity that has been out-sourced. Off-shoring on the other hand occurs when a company re-locates part of its production to a foreign location. Off-shoring of regional activities can be expected to exhibit similar feature to external out-sourcing in that although again, essentially, a new import would be replacing an activity previously accounted for in value added the region would lose any domestically produced intermediate inputs that serviced that part of the production process that has been moved. Other things being equal both off-shoring and external outsourcing might be expected to lead to less interconnectedness or complexity in the regional economy.

The factors outlined above suggest that one should not search for an analytic answer to the question of whether regional economies become more or less complex over time. However the existence of a consistent series of input-output tables at least allows one to examine empirical evidence relating to the issue, albeit empirical evidence that is for only one region and for only one relatively short-run period. Consistent, detailed Scottish input-output tables covering the period 1998 to 2007 have been published containing 126 separately identified industrial sectors. However three of these sectors are of little interest here. First, there was no activity attributed to the Tobacco sector over the whole period, second, the only activity attributed to the Sugar industry over the period was a small amount in 1998 so it has been subsumed into the Other food products sector and thirdly, the only activity attributed to the Metal ores extraction industry over the period were small amounts in 1998and 1999 so that has been subsumed into the Other mining and quarrying sector. As a result the analysis that follows is based on a 123 sector industrial disaggregation of the Scottish economy.

The rest of the paper is organised as follows. In the second section of the paper a simple summary measure of inter-connectedness is introduced. The third section presents the results of applying this aggregate measure to the Scottish tables. In section four of the paper an alternative measure, specifically designed to be applied at an individual sector level is introduced and then applied to the data in section five. The paper concludes with a brief commentary on the results.

2. A simple summary measure of Inter-connectedness

In this section attention is directed towards a measure of inter-connectedness that is a simple summary measure relating to the distribution of the input-output coefficients that can be derived from the original transactions tables. The basic relationships in the input-output framework are as follows

(a) The output of industry i is either used as an intermediate input in other industries $T_{i,j}$ j=1…n or is sold to final demand $F_{i,k}$ (where k represents Household consumption, Government consumption, Capital Formation or Exports etc.)

$$X_i = \sum_j T_{i.j} + \sum_k F_{i,k}$$

$$\text{or } X = T + F$$

(b) If we assume Leontiev technologies for each industry, the ratio of the intermediate input of i in industry j is a constant $a_{i,j}$

$$a_{i,j} = T_{i,j} / X_j$$

$$\text{thus } X_i = \sum_j a_{i.j} X_j + \sum_k F_{i,k}$$

$$\text{or } X = A.X + F$$

where A is the matrix of direct coefficients.

(c) Finally the system may be solved for output given a level of final demand

$$X = [I - A]^{-1} F = LF$$

where $L = [I - A]^{-1}$ is the Leontiev inverse matrix.

The measure of interconnectedness reported here, denoted by HJ, is the mean of the sums of the sector direct coefficients i.e. $HJ = (1/n)\sum_{i=1}^{n}\sum_{j=1}^{n} a_{i,j}$ a measure suggested by Hamilton and Jensen (1983). The larger are the intermediate coefficients the higher is the extent of internal transactions within the economy and the more interconnected or complex the economy is likely to be. Hamilton and Jensen find their measure to be among the more useful of the measures they consider and that seems to be confirmed by the recent findings of Wood and Lenzen (2009)

3. Results

The means of the sums of the sector direct coefficients of the 123-sector industry by industry tables are given in Table 1 and pictured in Figure 1. The implication of these figures is that over the period and certainly towards the end of the period studied, the Scottish economy became more interconnected though the increase may not appear to be dramatic. As might be expected, a similar pattern may be observed if one examines the average Leontiev open output multiplier over the period. The values of the average multiplier are also given in Table 1 and shown in Figure 2.

If the input-output coefficients increase (at least on average) over the period then, because of the accounting identity implicit in the columns of the table, this increase must be at the expense of other inputs into the production of goods and services. Each column of an input-output table may be divided into a set of elements relating to intermediate inputs, a set relating to imported inputs and a set relating to value added components. These relate to the costs of purchasing the commodities and factors necessary to produce Scottish output. It is possible to compare the movements, in aggregate, of the three shares corresponding to the three sets of costs for the period 1998 to 2007. For Scottish output as a whole the shares are shown in Figure 3. It can be seen that as the Scottish economy became more complex as a result of the increase in the intermediate input coefficients this was associated with a fall in the share of gross output accounted for by imports of intermediate goods and services. Value added, as a proportion of Gross Output varied little over the period. As a result one might infer that the increased complexity was a result of a degree of import substitution.

However if relatively more of Scottish output was being used as intermediate inputs into Scottish production not only does that imply something about the relative importance of imports and value added in the cost structure, it must also imply something regarding the sales of Scottish output. If relatively more is purchased by other firms as intermediate goods and services, relatively less must be sold to satisfy domestic final demand or be exported. The shares of output divided according to those three categories are shown in Figure 4. It can be seen that over the period 1998-2007 not only did the relative importance of intermediate use of Scottish goods and services increase in Scotland so did the relative share of Scottish output going to Scottish Domestic Final Demand (i.e. Consumers, Investment and Government). On the other hand relatively less of Scottish output was being exported at the end of the period (26.3%) than at the start (33.8%). It is worth stressing that the fall in the shares of imports and exports in Scottish Output over the period are not a result of actual falls in the value of Imports and Exports. Imports of intermediate goods and services rose by 22.2% and Exports of Scottish produced goods and services by 19.9%. However Scottish Gross Output grew by 54.4% over the same period.

4. Hypothetical Extraction

A second way of examining the interconnectedness of an input-output table is to calculate, for each sector in turn, the effect on the economy of that sector. This can be done by the hypothetical extraction method (Miller and Blair, 2009). Suppose, without loss of generality, that the first sector is to be extracted. The original system may be partitioned to show that sector separately.

$$A = \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & A_{22} \end{pmatrix}$$

The extraction method then considers a revised version of this matrix in which the elements of the first row and column are changed

$$A^* = \begin{pmatrix} a^*_{11} & a^*_{12} \\ a^*_{21} & A_{22} \end{pmatrix}$$

Then the effect on the economy of the change is given as

$$\Delta X = \left[(I - A)^{-1} - \left(I - A^*\right)^{-1} \right] F$$

There are a number of minor variants of the method which differ in the treatment of the elements in the row and column pertaining to the extracted sector in the matrix of direct coefficients. Dietzenbacher and van der Linden (1997) set the column elements equal to zero. Cella (1984) sets the row and column elements equal to zero apart from the intra-sectoral element in the extracted row and column which is not changed. Finally Groenewold, Haggar and Madden (1993) set all row and column elements for the extracted sector equal to zero. It is this last approach, sometimes referred to as Industry shutdown, which is undertaken here. However it should be noted that the estimated effect on the rest of the economy of extracting any given sector is identical whichever of the methods is chosen. (Appendix 12W.1, Miller and Blair, 2009[2])

5. Shutdown Results

Figure 5 shows, for the whole set of 123 industries, the flow-on effects of shutting down that industry. It should be noted that the figures are relative figures in

[2] http://www.cambridge.org/resources/0521739020/7512_Appendix%2012W.1%2027%20Jul%202009.pdf

that the flow-on effects are expressed as the flow-on effects relative to the original size of the shutdown sector. That is to say that, for example, for Sea Fishing in 1998, the value of 0.488 plotted on in Figure 5 implies that a shutdown of the sector which in that year had a gross output of £266.3m would have had a flow-on effect of 0.554 * £266.3m = £129.9m on the rest of the Scottish economy.

Inspection of Figure 5 might lead one to conclude, albeit with some uncertainty, that the majority of the lines were sloping upward from left to right and thus there may well have been a gradual increase in interconnectedness in the Scottish economy over the period. However because the figures from which the graph is constructed are relative figures this may not be a valid conclusion. In Figure 5 all industries are equally important. In reality this is not the case. The construction industry with, in 2007, a gross value added of £7557.4m is considerably more important in the Scottish economy than Footwear with a gross value added of £0.4m. In order to summarize the information in Figure 5 a weighted average of the flow-on effects has been calculated, the weights being the gross value added of the industries. The resultant series is shown in Figure 6. Although this graph exhibits a slightly different pattern to Figures 1 and 2 it is still the case that it is upward sloping from left right and thus the hypothetical extraction methodology confirms the result that the Scottish economy was become more complex over the period 1998 – 2007.

Although this is an aggregate result it is instructive to examine the relationships, if any, at an industry level that exist between the movements in the flow-on effects and the level of GVA (gross value added) over the period. In all cases growth rates were calculated by estimating the slope coefficient in a simple regression model of the logarithm of either the flow-on effect or of GVA against a time index. Three significant findings emerge form this analysis. First, the relative flow-on effects tend to be larger for less important (in terms of GVA) industries. ($r = -0.244$) suggesting that smaller industries are, on average, more embedded in the Scottish economy than larger industries. Second, the growth rates of the flow-on factors are also negatively correlated with GVA ($r = -0.260$) suggesting that the smaller industries are increasing their degree of embeddedness at a faster rate than larger industries. Finally, the growth rates of the flow-on effects are negatively correlated to the growth rates in GVA ($r = -0.261$)

indicating that the faster growing industries in Scotland were not increasing their embeddedness as quickly as slower growing industries were.

6. Conclusion

The evidence supports the idea that the Scottish economy became more inter-related or complex over the turn of the millennium just as Scotland achieved a measure of devolution. The aggregate results reported in the first half of this paper appear to support the idea that the increasing inter-connectedness of the economy was accompanied by a shift from using imported inputs into the production process in favour of domestically produced inputs. It would appear that if the Scottish economy has undergone a process of globalization that process has not let to any "hollowing-out" of the economy.

The results of applying a variant of the extraction method reinforced the view that inter-connectedness within the Scottish economy increased over the period. However it might be of concern to policy makers that it is the smaller industries that have greater linkages within the Scottish economy and are increasing these linkages faster than larger industries and further that less dynamic industries are increasing their linkages faster than the more dynamic industries. Whether it is generally true that faster growing industries in a region are likely to increase their inter-relationships with the local economy at a slower than average rate, is something that requires a more extensive study than this.

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Table 1: The Mean of the Direct Coefficients and the average Leontiev Multiplier, 1998 - 2007

Year	HJ[1]	ALM[2]
1998	0.2597	1.3649
1999	0.2584	1.3599
2000	0.2552	1.3566
2001	0.2662	1.3787
2002	0.2637	1.3796
2003	0.2676	1.3829
2004	0.2664	1.3817
2005	0.2842	1.4199
2006	0.2914	1.4367
2007	0.2900	1.4327

[1] $HJ = (1/n)\sum_{i=1}^{n}\sum_{j=1}^{n} a_{i,j}$

[2] Average Leontiev Type I Multiplier

Figure 1: The mean of the sums of the sector direct coefficients

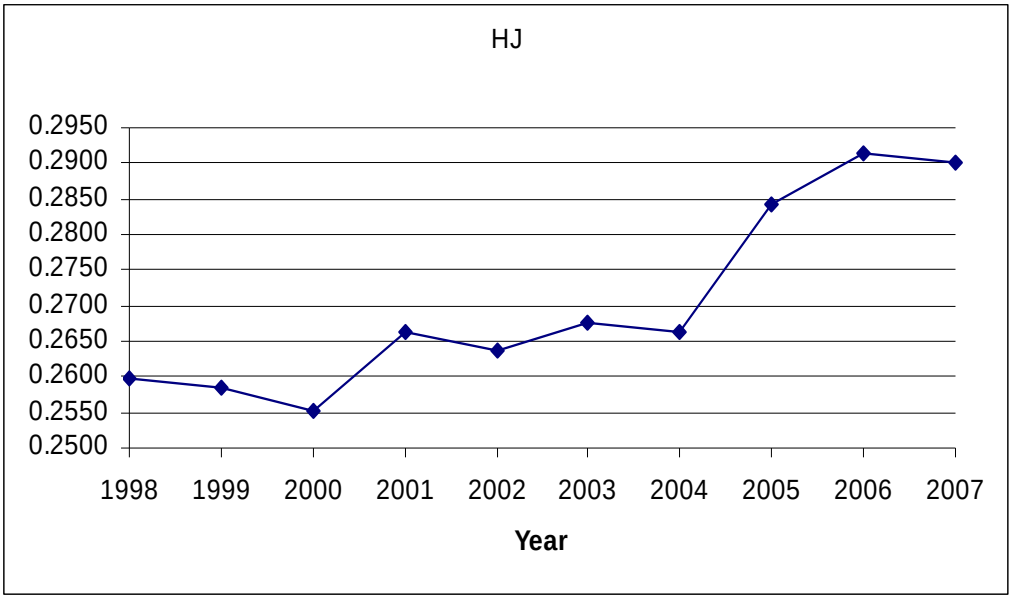

Figure 2: The average value of the Leontiev open output multiplier

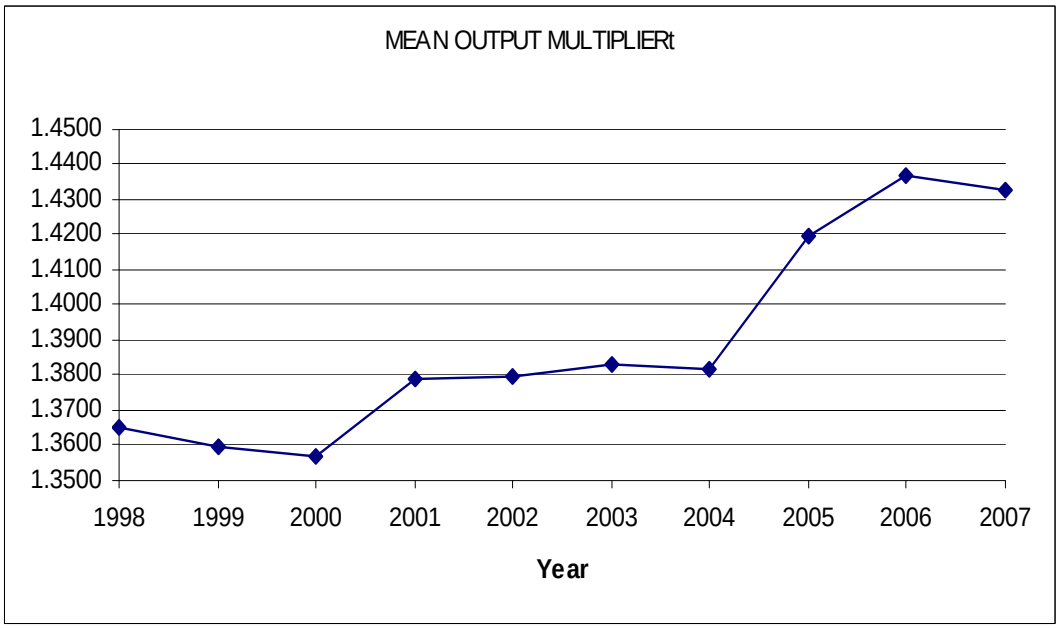

Figure 3: Gross Output Shares by cost (All industries) 1998 - 2007

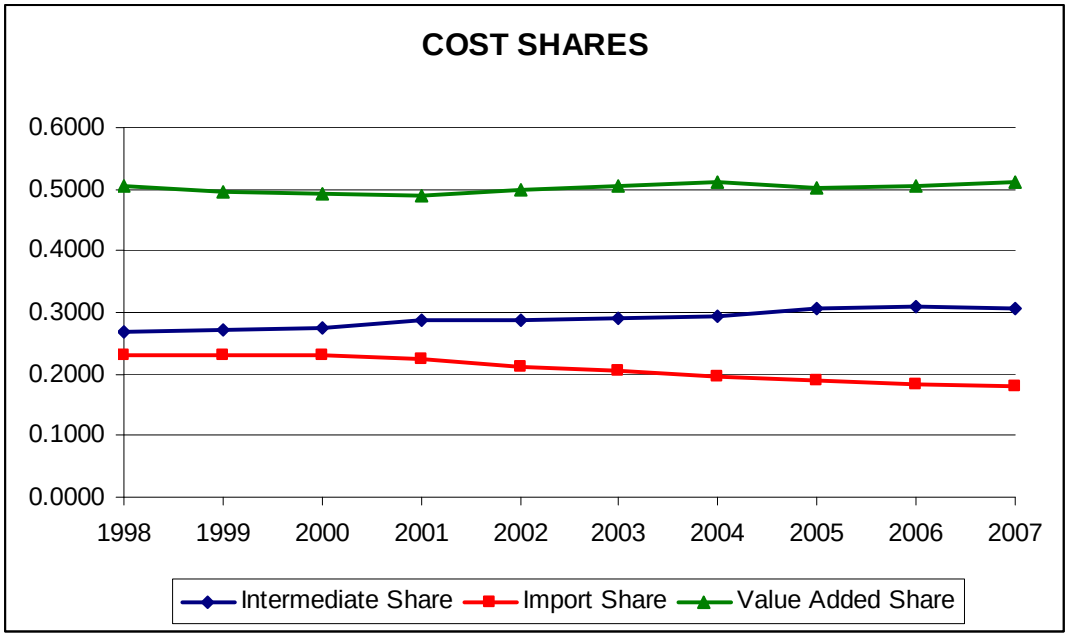

Figure 4: Gross Output Shares by sales (All industries) 1998 – 2007

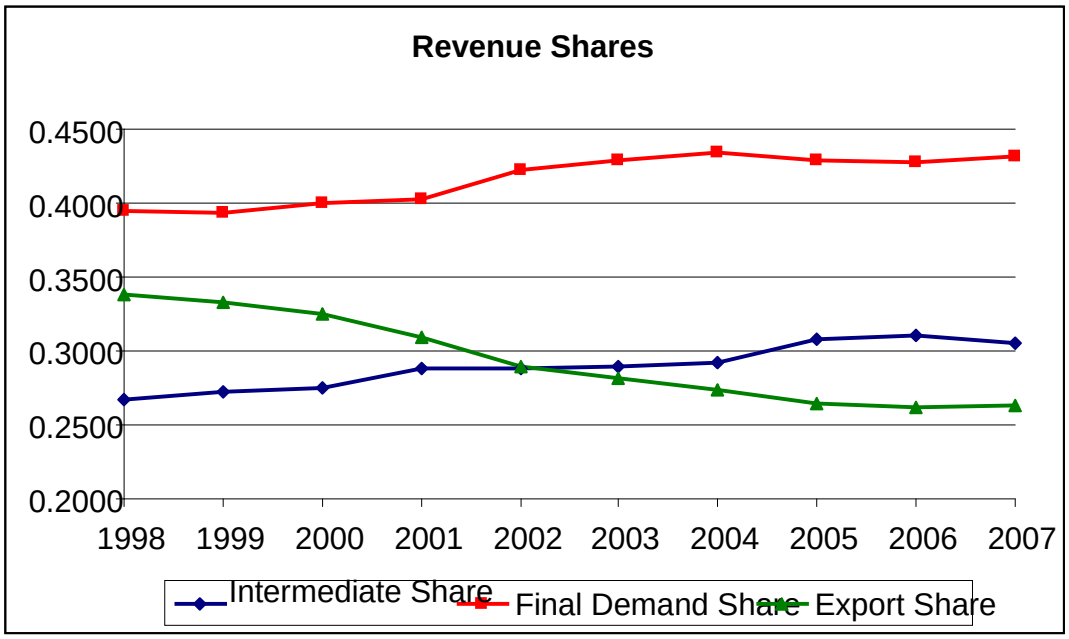

Figure 5: Shutdown Flow-on effects (relative to industry output) 1998-2007 [123 Industries]

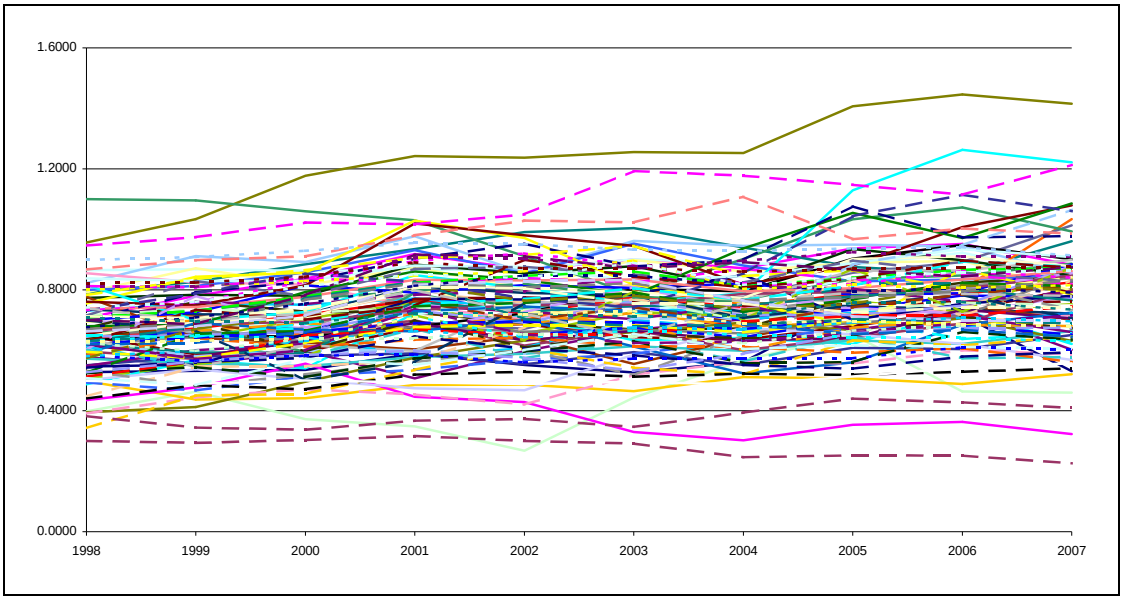

Figure 6: Weighted Mean of Shutdown Flow-on Effects by industry, 1998 – 2007